EVALUATION OF THREE CANDIDATE CYPERMETHRIN-PIPERONYL BUTOXIDE FORMULATIONS COMPARED WITH SCOURGE® AGAINST ADULT *CULEX QUINQUEFASCIATUS*

T. G. FLOORE, J. C. DUKES, A. H. BOIKE, JR., M. J. GREER AND J. S. COUGHLIN

John A. Mulrennan, Sr. Research Laboratory, 4000 Frankford Avenue, Panama City, FL 32405

ABSTRACT. Cypermethrin-piperonyl butoxide formulations (1:1, 1:5, 1:10) were evaluated in a laboratory wind tunnel against colony reared, susceptible adult *Culex quinquefasciatus* mosquitoes. Scourge® (4% resmethrin:12% piperonyl butoxide) was used as the standard for comparison. Based on the LC_{90} data, the 3 cypermethrin-piperonyl butoxide formulations were 2.6–3.7× more toxic than Scourge 24-h posttreatment.

Cypermethrin, a broad spectrum synthetic pyrethroid insecticide, has proven effective in controlling adult mosquitoes (Helson and Surgeoner 1983, Roberts 1983) and Helson and Surgeoner (1986) found it to be an effective larvicide. However, cypermethrin can enhance cross-resistance in mosquitoes (Priester and Georghiou 1980).

The John A. Mulrennan, Sr. Research Laboratory (JAMSRL) laboratory wind tunnel is used to determine through bioassay and statistical analysis the efficacy of candidate insecticides, and compare the results to standard labeled insecticides. Synthetic pyrethroid insecticide formulations tested at JAMSRL have included several permethrin formulations (Floore et al. 1990), Bioresmethrin® and Esbiothrin® (Floore et al. 1992). In this study, the effectiveness of 3 cypermethrin-piperonyl butoxide (C/PB) formulations compared with Scourge® were evaluated against adult *Culex quinquefasciatus* Say.

Three candidate C/PB formulations (1:1, 1:5, 1:10 by volume) supplied by Clarke Mosquito Control Products, Inc., Roselle, IL, containing 47.42, 16.41 and 9% cypermethrin, respectively, were evaluated. Scourge contains a 1:3 formulation of 4% resmethrin and 12% PB and was used as a standard for comparison.

Laboratory reared 6–8 day old *Cx. quinquefasciatus* adults were exposed in laboratory wind tunnel tests as described by Rathburn (1969) and Floore et al. (1990). Five to 8 serial dilutions of each formulation were tested to determine the percent knockdown and 24-h posttreatment mortalities. Mortality data were corrected with Abbott's formula (Abbott 1925). The LC_{50}, LC_{90}, corresponding 95% confidence limits and standard error were calculated by probit analysis. The LC_{50} and LC_{90} values were used to calculate toxicity ratios (TR_x) to compare the formulation's efficacy as follows:

$$\text{Toxicity ratio } (TR_x) = \frac{LC_{50} \text{ or } LC_{90} \text{ of standard insecticide}}{LC_{50} \text{ or } LC_{90} \text{ of candidate insecticide}}$$

A toxicity ratio greater than 1 indicated that the candidate insecticide formulation was more toxic than the standard. Results were contrasted with previously published studies of permethrin, Bioresmethrin and Esbiothrin formulations using similar testing methods.

All the C/PB formulations were more effective than Scourge, the standard, against *Cx. quinquefasciatus* 24-h posttreatment (Table 1). The 1:5 and 1:10 C/PB formulations were 5.7× more effective than Scourge at the LC_{50} level and 2.9 and 3.7× respectively, more effective at the LC_{90} level.

The C/PB formulations were more effective against *Cx. quinquefasciatus* adults than permethrin/PB formulations (Floore et al. 1990). A 1:10 C/PB formulation was 3× more toxic than a 4:20 permethrin/PB formulation at the LC_{90} level 24-h posttreatment and 11× more effective than technical permethrin (92%). Against adult *Cx. quinquefasciatus* 24-h posttreatment, a 1:10 C/PB formulation was 7× more toxic than Permanone® 10EC (10% permethrin) at the LC_{90} level. Compared with 2% Bioresmethrin, C/PB (1:10) was 3× more toxic and 6× more toxic than 2% Esbiothrin 24-h posttreatment at the LC_{90} level (Floore et al. in press).

Adult mosquitoes treated with C/PB demonstrated physiological activities similar to those treated with permethrin formulations. However, there was no rapid paralysis and/or loss of legs as observed in mosquitoes treated with Esbiothrin or Bioresmethrin (Floore et al. in press). Knockdown is an important consideration in the application of synthetic pyrethroids. The highest cypermethrin dilutions demonstrated excellent knockdown capability 1-h posttreatment (>90%) and caused more than 90% mortality 24-h posttreatment. Caution must be exercised to avoid misuse of effective, broad spec-

Table 1. Laboratory adulticide tests of 3 cypermethrin/PB formulations compared to Scourge® against *Culex quinquefasciatus* 24-h posttreatment.

Insecticide	Lethal concentration in mg AI/ml					Toxicity ratio[1]	
	LC_{50}	95% CL	LC_{90}	95% CL	±SE	LC_{50}	LC_{90}
Cypermethrin (1:1)	0.0133	0.0124–0.0143	0.0471	0.0413–0.0549	0.11	4.2	2.6
Cypermethrin (1:5)	0.0098	0.0091–0.0107	0.0418	0.0362–0.0497	0.11	5.7	2.9
Cypermethrin (1:10)	0.0099	0.0093–0.0106	0.0328	0.0292–0.0377	0.13	5.7	3.7
Scourge	0.0561	0.0537–0.0585	0.1222	0.1149–0.1313	0.17	—	—

[1] = if the toxicity ratio is >1, then candidate insecticide more effective.

trum pyrethroids such as cypermethrin. In the state of Florida organophosphorus insecticide resistance has already been demonstrated (Boike et al. 1980, 1990).

In summary all the C/PB formulations were more effective than Scourge against adult *Cx. quinquefasciatus* in a laboratory wind tunnel test 24-h posttreatment. The most toxic formulation was the 1:10 cypermethrin/piperonyl butoxide.

REFERENCES CITED

Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol. 18:265–317.

Boike, A. H., Jr., C. B. Rathburn, Jr., C. F. Hallmon and R. L. Wells. 1980. Monitoring for resistance in mosquitoes from several selected areas in Florida for 1979. Proc. Fla. Anti-Mosq. Assoc. 51:47–51.

Boike, A. H., Jr., C. B. Rathburn, Jr., T. G. Floore, H. M. Rodriguez and J. S. Coughlin. 1990. Insecticide tolerance of *Culex nigripalpus* in Florida. J. Am. Mosq. Control Assoc. 5:522–528.

Floore, T. G., C. B. Rathburn, Jr., A. H. Boike, Jr. and J. S. Coughlin. 1990. Laboratory wind tunnel tests of four permethrin-piperonyl butoxide formulations compared with Scourge® against caged adult *Culex quinquefasciatus*, *Culex nigripalpus* and *Aedes taeniorhynchus*. J. Fla. Mosq. Control Assoc. 61:9–12.

Floore, T. G., C. B. Rathburn, Jr., A. H. Boike, Jr., J. S. Coughlin and M. J. Greer. 1992. Evaluation of 2% Esbiothrin® and 2% Bioresmethrin® compared to Scourge® and Cythion® against adult *Aedes taeniorhynchus* and *Culex quinquefasciatus* in a laboratory wind tunnel. J. Am. Mosq. Control Assoc. (in press).

Helson, B. V. and G. A. Surgeoner. 1983. Permethrin as a residual lawn spray for adult mosquito control. Mosq. News 43:164–169.

Helson, B. V. and G. A. Surgeoner. 1986. Efficacy of cypermethrin for the control of mosquito larvae and pupae and impact on non-target organisms, including fish. J. Am. Mosq. Control Assoc. 2:269–275.

Priester, T. M. and G. P. Georghiou. 1980. Cross-resistance spectrum in pyrethroid-resistant *Culex quinquefasciatus*. Pestic. Sci. 11:617–624.

Rathburn, C. B., Jr. 1969. A laboratory thermal aerosol generator for the testing of insecticidal aerosols. Mosq. News:29:1–6.

Roberts, R. H. 1983. Evaluation of cypermethrin as an ULV cold aerosol against caged mosquitoes. Mosq. News 43:156–158.